

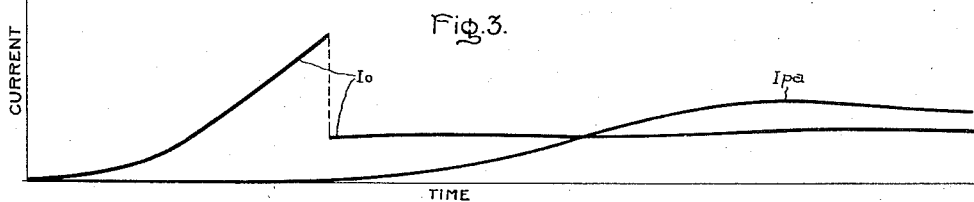
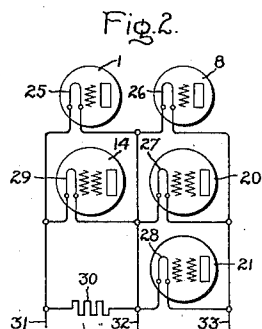
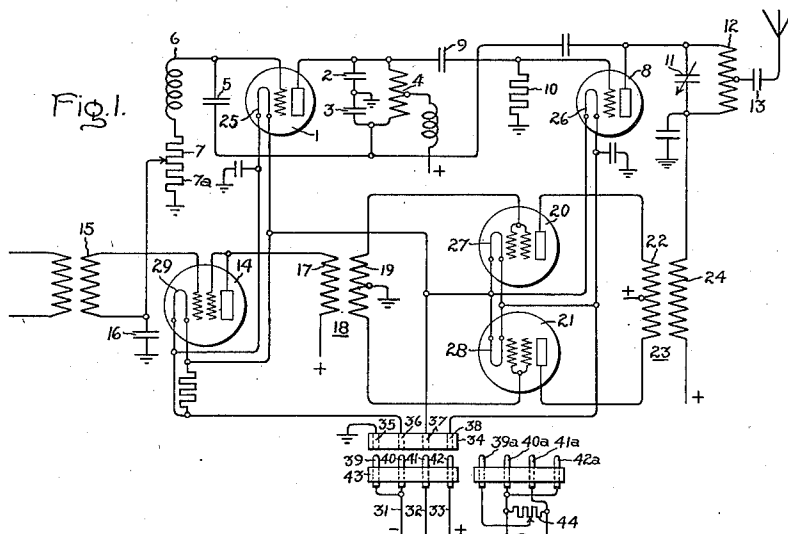
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RADIO TRANSMITTING SYSTEM

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RADIO TRANSMITTING SYSTEM

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16 Claims. (Cl. 250—17)

My invention relates to radio transmitting systems and more particularly to a system of the master oscillator power amplifier type and the method of operating the same.

In the use of radio transmitting apparatus in certain types of installations, it is necessary to include electron discharge devices of commercial design in the transmitting circuits and adapt these devices to the sources of current supply which are available, without unduly complicating the apparatus. Thus, for example, in automobile installations, in order to operate the standard electron discharge devices requiring two and one-half volts as a normal heater potential, it is necessary, to achieve the most efficient operation, to connect the heaters of the devices in series parallel relation across the standard six volt battery with which such cars are normally equipped. Certain types of transmitting circuits, such as some master oscillator power amplifier types, have as a definite requirement for satisfactory operation that upon starting the transmitter certain portions of the circuit begin to operate before others. Thus, in the specific type of transmitting circuit described hereinafter, it is imperative for continued satisfactory operation that the oscillator, which furnishes the control potential to the control circuit of the power amplifier, be in normal operation when the amplifier starts to function. This is necessary to protect the power amplifier electron discharge device from the effect of an abnormal anode current which will flow through the device if electron emission starts in the device with no biasing potential on its control electrode, and to insure the proper functioning of the circuit during the starting period. I have found that the most efficient method of solving the problem is to bring the cathode of the electron discharge device included in that branch of the circuit to be started first to its emission temperature before the cathode of the electron discharge device to be controlled reaches its normal electron emitting temperature.

My invention has for one of its objects to provide a new and improved method and means for initiating the operation of a radio transmitting system.

A further object of my invention is to provide an improved radio transmitting apparatus circuit so arranged that, during the starting period of the apparatus, the operation of the power amplifier will be delayed until the oscillator which controls the power amplifier has attained its normal operating condition.

An additional object of my invention is to pro-

vide an improved cathode heater circuit arrangement for a radio transmitter of the master oscillator power amplifier type, such that during the starting period of the transmitter the cathode of the oscillator tube will be heated to its normal electron emitting temperature before the cathode of the power amplifier tube reaches its normal emitting temperature.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken with the accompanying drawing, in which Fig. 1 shows my improved circuit for a radio transmitter; Fig. 2 is a simplified diagram of the cathode heater circuit of Fig. 1; and Fig. 3 illustrates certain operating characteristics of the apparatus.

Referring to Fig. 1 of the drawing, I have shown a radio transmitter of the master oscillator-power amplifier type which includes an oscillator of the well-known feed-back type comprising an electron discharge tube 1 and a tuned circuit consisting of the series connected condensers 2 and 3 having the series connection grounded, and an inductance 4. The tuned circuit is capacitively coupled by means of the condenser 5 to the input circuit of the oscillator. The input circuit consists of the radio frequency choke coil 6 connected to the electron discharge tube 1 in series with a grid resistance 7. The frequency of the oscillations produced by the oscillator is controlled by the constants of the tuned circuit consisting of the condensers 2 and 3, and the inductance 4, which circuit feeds a portion of its energy back to the control grid of the tube 1 through the coupling condenser 5, thus maintaining the tube 1 in an oscillating condition, in a manner well known in the art.

The radio frequency voltage generated by the oscillator is amplified by a power amplifier tube 8 which is coupled to the oscillator by means of an input circuit including a condenser 9 and a resistance 10. The output of the power amplifier is impressed on the antenna circuit through the tuned circuit comprising a condenser 11 and inductance 12, and an antenna coupling condenser 13.

The oscillator and power amplifier tubes shown are of the three element electron discharge type having a directly heated cathode and possess identical operating characteristics; but it will be understood that the tubes may be of the indirectly heated cathode type, and may possess dif-

ferent operating characteristics if the requirements of a particular circuit so demand. In this specification I use the term "heater" in a generic sense and as applying both to filamentary cathodes of the discharge devices employed or to the heating elements of the cathodes if unipotential cathode electron discharge devices be employed.

A signal amplifier is provided for amplifying without substantial distortion the full wave signal voltage generated by a signal source (not shown) such as a microphone, or the like. As shown, the input circuit for the signal amplifier tube 14 includes the control grid of the tube 14, the secondary 15 of a coupling transformer whose primary is fed from the signal source, the portion 7a of the resistor 7 and the by-pass condenser 16. The unidirectional component of the grid current of the oscillator tube 1 flowing through the variable portion 7a of the resistance 7 provides the grid bias for the signal amplifier tube 14. The amplifier tube 14 is of the four electrode type having the second control electrode thereof connected to the anode, which connection enables the tube to operate in a well known manner to amplify without substantial distortion the full signal wave impressed thereon.

The amplified signal currents from the tube 14 are impressed on the primary 17 of a coupling transformer 18, having a secondary 19 which supplies a control potential to the grids of the modulator amplifier tubes 20 and 21. The modulator amplifier tubes are connected in "push-push" relation in a manner well understood in the art and fully illustrated and described in Patent 1,699,110 to Loughren, issued January 15, 1929. The output from the modulator amplifier tubes is impressed on the primary 22 of a modulation transformer 23 having its secondary 24 connected in the antenna circuit. The current flowing in the secondary 24 serves to increase and decrease (modulate) the amplitude of the carrier current, generated by the oscillator 1 and amplified by the power amplifier 8, in accordance with the signal current appearing across the signal transformer secondary 15. A single high voltage source in the form of a small dynamotor (not shown) energized by any available low voltage supply source, is provided for supplying energy to the various anode circuits. This source has its negative side grounded and its positive side connected to the various leads indicated.

During normal operation of the above described apparatus, the carrier voltage generated by the oscillator is amplified by the power amplifier including the tube 8 and is modulated by the amplified signal currents appearing across the secondary 24 of the transformer 23. It will be noted that the only potential for biasing the control electrode of the amplifier tube 8 is supplied by rectification, in the grid circuit of that tube, of the output current from the oscillator; the rectified current flowing through the grid resistance 10. It is imperative that such a biasing potential be impressed on the control electrode of the power amplifier tube when normal plate voltage is impressed on the anode circuit and the cathode is at its normal electron emitting temperature, in order to prevent an abnormal current from flowing in the anode circuit of the power amplifier tube 8. Such an abnormal current is undesirable since it causes direct injury to the tube by destroying the coating of electron emitting substance on the cathode thereof; and also causes a very great decrease in the internal cathode-anode impedance of the tube, thereby overloading the

dynamotor which supplies voltage to the various anode circuits. Furthermore, operation of the amplifier tube at such high plate currents gives rise to gaseous currents within the tube; which in turn lower the grid-cathode impedance of the tube and thus cause the oscillator to be overloaded. This overloading of the elements noted materially delays the starting of the normal operation of the apparatus and may, under certain conditions, result in a total failure of the apparatus to assume a stable operating condition. It will be seen, therefore, that it is necessary that the oscillator be in normal operation when the power amplifier starts to operate, if the necessary control potential to prevent an undesired abnormal current in the anode circuit of the power amplifier is to be available.

Referring to Fig. 2 I have shown the cathode heater circuit included in the transmitting apparatus illustrated in Fig. 1 arranged in a manner which will effect the desired operation outlined in the preceding paragraph. As shown, the cathode heater 25 of the oscillator tube 1 is connected in series with the cathode heater 26 of the amplifier tube 8 across a low voltage source of potential which is equal to approximately twice the normal voltage rating of the respective cathode heaters. This series connection of the heaters is desirable in certain applications where a single low voltage source is the only available current supply. For example, in an automobile transmitter installation, an ordinary six volt storage battery is, in the absence of special apparatus, the only current supply source available and since the rated heater voltage of the standard commercial tubes adapted for use in the type of circuit illustrated is approximately two and one-half volts, it will be seen that it is expedient to connect the heaters in series across the source to achieve the greatest efficiency. I have shown the heaters 27 and 28 of the modulator amplifier tubes connected in parallel with the heater 26 of the power amplifier tube, and the heater 29 of the signal amplifier tube connected in parallel with the heater 25 of the oscillator tube. A resistance 30 having a substantially constant or inverse temperature coefficient of resistance is connected in parallel with the heater 25 of the oscillator tube to balance the circuit so that all of the tubes in the series parallel circuit will draw their rated currents under normal operating conditions. The respective heaters shown possess a high positive temperature coefficient of resistance such that the cold resistance is approximately one tenth that of the hot resistance.

The operation of the circuit to attain the previously described desired operation of the transmitter during the starting period may be best understood by considering the circuit as divided into two parallel circuits connected in series across the supply source. Thus the parallel circuit at the left includes the heater 25 shunted by the heater 29 and the resistance 30 across the leads 31 and 32, and the parallel circuit at the right includes the heater 26 shunted by the heaters 27 and 28 across the leads 32 and 33. Assuming that the heaters 27, 28 and 29 possess identical resistance characteristics, and that the heaters 25 and 26 also have identical characteristics, it will be seen that when all of the heaters are cold, the effective resistance of the parallel circuit including the heaters 25 and 29 and the resistance 30 will be greater than the effective resistance of the parallel circuit including the heaters 26, 27 and 28 since the balancing resist-

ance 30 has a cold resistance several times greater than the cold resistance of the heaters. It necessarily follows that during the starting period of the apparatus the voltage across the parallel circuit including the heater 25, and hence the voltage across the heater 25, will be greater than the voltage across the heater 26. This means that the current flowing through the heater 25 will be greater than the current flowing through the heater 26, whereby the cathode of the oscillator tube 1 will be heated to its normal electron emitting temperature before the cathode of the power amplifier tube 8 is heated to its normal electron emitting temperature. By virtue of the above operation of the cathode heater circuit the oscillator will start to function before the power amplifier and hence it will be appreciated that a control biasing potential will be impressed on the input circuit of the power amplifier before normal anode current flows through the power amplifier tube.

The advantage of the above described circuit is clearly indicated by a consideration of the starting characteristics of the power amplifier tube and the oscillator tube as shown in Fig. 3, which reproduces an oscillogram taken on the circuit of Fig. 1 and in which the curve designated I_{pa} shows the rise in the power amplifier tube anode current as the apparatus starts to function and the curve I_o designates the current flowing in the anode circuit of the oscillator tube. It will be seen that the curve I_{pa} rises gradually from a zero value to its normal operating value. It will further be noted that the oscillator reaches a stable operating condition a very short time interval after voltage is applied across the cathode heater circuit leads and before the anode current of the amplifier has built up to any value likely to cause injury to the electron discharge device employed.

Referring again to Fig. 1, I have shown a convenient means for connecting the cathode heater circuit to a source of supply current comprising a terminal block 34 having receptacles 35, 36, 37 and 38 for receiving the plugs 39, 40, 41 and 42 mounted on the plug block 43. In practicing my invention current is supplied to the cathode heater circuit leads 31 and 32 through the plugs 40 and 42 and the receptacles 36 and 38, the negative side of the cathode heater circuit being connected to ground by means of the plug 39 and receptacle 35. If it be desired to connect the tube heaters all in parallel across a source of alternating potential equal to the voltage rating of the heaters the plug connections may be made as shown at the right wherein the plugs 40a and 42a are connected together and the ground plug 39a is tapped to a resistor 44 shunting the alternating current supply source.

While I have shown particular embodiments of my invention it will, of course, be understood that I do not wish to be limited thereto since various modifications may be made. I contemplate by the appended claims to cover any modifications which fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of starting a radio transmitter of the master oscillator power amplifier type which includes heating the cathode of the oscillator tube to its normal electron emission temperature before the cathode of the amplifier tube is heated to its normal electron emission temperature.

2. Radio transmitting apparatus including a power amplifier, an oscillator adapted to control said amplifier, a cathode heater circuit including the heaters of said amplifier and said oscillator tubes, and means connected in said circuit for reducing during the starting period of the apparatus the rate of heating of the cathode of said amplifier until said oscillator has attained its normal operating condition.

3. Radio transmitting apparatus including a first electron discharge tube, means including a second electron discharge tube for controlling said first electron discharge tube, each of said tubes having an anode and a heater, said first electron discharge tube being subject to an abnormal anode current in the absence of the controlling action of said control means, a current supply source, said heaters being connected in series across said source, and means connected in circuit with said heaters for delaying during the starting period of the apparatus the heating of the cathode of said first electron discharge tube until said second electron discharge tube has attained a normal operating condition thereby to establish normal operation of said control means before said first electron discharge tube attains its normal operating condition.

4. Radio transmitting apparatus including a first electron discharge tube having a heater and a control electrode, means including a second electron discharge tube having a heater for supplying a control potential to the control electrode of said first tube, a source of current supply, said heaters being connected in series across said source, and means including a resistance having a high positive temperature coefficient of resistance and connected in parallel with the heater of said second electron discharge tube for delaying during the starting period of the apparatus the operation of said first electron discharge tube until said second electron discharge tube has attained its normal operating condition.

5. Radio transmitting apparatus including a power amplifier, an oscillator for controlling said power amplifier, a current supply source, said amplifier and oscillator including electron discharge tubes each having a heater, said heaters being connected in series across said source and means connected in circuit with said heaters for delaying during the starting period of the apparatus the heating of the cathode of said power amplifier tube until said oscillator tube has attained a normal operating condition.

6. Radio transmitting apparatus including a power amplifier, an oscillator for controlling said power amplifier, a current supply source, said amplifier and oscillator including electron discharge tubes each having a heater, said heaters being connected in series across said source, and means electrically associated with said heaters for maintaining the current flowing through said oscillator tube heater at a value greater than the value of the current flowing through said amplifier tube heater during the starting period of said apparatus.

7. Radio transmitting apparatus including a power amplifier electron discharge tube having a heater and a control electrode, means including an oscillator electron discharge tube having a heater for supplying a control potential to the control electrode of said power amplifier tube, a source of current supply, said tube heaters being connected in series across said supply source, and means including means connected in parallel with said amplifier tube heater for delaying dur-

ing the starting period of the apparatus the operation of the power amplifier tube until the oscillator tube has attained a normal operating condition.

8. Radio transmitting apparatus including a power amplifier electron discharge tube having a heater and a control electrode, means including an oscillator electron discharge tube having a heater for supplying a control potential to the control electrode of said power amplifier tube, a source of current supply, said tube heaters being connected in series across said supply source, and means including a resistance having a high positive temperature coefficient of resistance shunting the heater of said power amplifier tube for delaying during the starting period of the apparatus the operation of the power amplifier tube until the oscillator tube has attained a normal operating condition.

9. Radio transmitting apparatus including a power amplifier electron discharge tube having a heater and a control electrode, means including an oscillator electron discharge tube having a heater for supplying a control potential to the control electrode of said power amplifier tube, a current supply source, a heater circuit including the heaters of said tubes connected in series across said source and means including a resistance having a high positive temperature coefficient of resistance shunting the heater of said power amplifier tube and a resistance having a substantially constant temperature coefficient of resistance shunting the heater of said oscillator tube for delaying during the starting period of the apparatus the operation of the power amplifier tube until the oscillator tube has attained a normal operating condition.

10. In combination, a first electron discharge device, means including a second electron discharge device, for controlling said first electron discharge device, each of said electron discharge devices having an anode and a cathode, said first electron discharge device being subject to an abnormal anode current in the absence of the controlling action of said control means, and means for simultaneously energizing the cathodes of said electron discharge devices, said last-named means including means to delay during the starting operation of said discharge devices the heating of the cathode of said first discharge device until said second discharge device has attained its normal operating condition thereby to establish normal operation of said control means before said first discharge device attains its normal operating condition.

11. In combination, a first electron discharge device, means including a second electron discharge device for controlling said first electron discharge device, each of said electron discharge devices having an anode and a cathode, said first electron discharge device being subject to an abnormal anode current in the absence of the controlling action of said control means, and means for heating the cathodes of said discharge devices, said last-named means including means to heat the cathode of said second discharge device to its normal electron emission temperature before the cathode of said first electron discharge device reaches its electron emission temperature thereby to establish normal operation of said control means before said first electron discharge device attains its normal operating condition.

12. In a transmitting apparatus including an amplifier, the combination of an oscillator for controlling said amplifier, said amplifier and os-

cillator each including an electron discharge device having a cathode, and means for simultaneously applying energizing voltage to the cathodes of said electron discharge devices, and means to delay, during the starting period of the apparatus, the heating of said amplifier cathode until said oscillator has attained its normal operating condition.

13. In a transmitting apparatus, the combination of an electron discharge amplifier having a heater and a control grid, means including an electron discharge oscillator having a heater for supplying a control potential to the control grid of said amplifier, a modulator including a plurality of electron discharge devices, each having a heater and adapted to modulate the output current of said amplifier, a source of supply current, said oscillator heater and said power amplifier heater being connected in series across said source, and means connecting the heaters of the electron discharge devices of said modulator in parallel with the heater of said amplifier thereby to delay, during the starting period of the apparatus, the operation of the amplifier until the oscillator has attained a normal operating condition.

14. In a transmitting apparatus including an electron discharge amplifier having a heater and a control electrode, the combination of means including an electron discharge oscillator having a heater for supplying a control potential to the control electrode of said amplifier, a modulator including a plurality of electron discharge devices each having a heater and adapted to modulate the output current of said amplifier, a source of supply current, said heaters of said oscillator and said amplifier being connected in series across said source, and means including the heaters of said electron discharge devices of said modulator connected in parallel with said amplifier tube heater and a resistance having a substantially constant temperature coefficient connected in shunt with said heater of said oscillator for delaying, during the starting period of the apparatus, the operation of the amplifier until the oscillator has attained a normal operating condition.

15. In transmitting apparatus including an electron discharge amplifier tube having a heater and a control electrode, means including an electron discharge oscillator having a heater for supplying a control potential to the control electrode of said power amplifier tube, a modulator including a plurality of electron discharge devices each having a heater and a control electrode, said modulator being connected to modulate the output current of said amplifier, means including an electron discharge signal amplifier having a heater for supplying a control potential to the control electrodes of said electron discharge devices of said modulator, a source of supply current, said heaters of said oscillator and power amplifier being connected in series across said source, and means including said heaters of said electron discharge devices of said modulator connected in parallel with said heater of said power amplifier and the heater of said signal amplifier connected in parallel with said oscillator tube heater for delaying during the starting period of the apparatus the operation of the electron discharge device of said oscillator until said amplifier has attained a normal operating condition.

16. Radio transmitting apparatus including an electron discharge power amplifier having a heated cathode element and a control electrode, means

including an electron discharge oscillator having a heated cathode element for supplying a control potential to the control electrode of said power amplifier, a modulator including a plurality of electron discharge devices each having a heated cathode element and a control electrode, said modulator being arranged to modulate the output current of said power amplifier, means for supplying a control potential to the control electrodes of said modulator tubes, said means including a signal amplifier tube having a heated cathode element, a source of supply current, heated elements of said oscillator and said power amplifier being connected in series across said source, and means including heated elements of said electron discharge devices of said modulator connected in parallel with the heated elements of said power amplifier and the heated elements of said signal amplifier connected in parallel with both that of said oscillator and a resistance having a substantially constant temperature coefficient for delaying, during the starting period of the apparatus, the operation of the electron discharge device of said power amplifier until the electron discharge device of said oscillator has attained a normal operating condition.

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DISCLAIMER

2,065,369.— *George W. Fyler*, Schenectady, N. Y. RADIO TRANSMITTING SYSTEM.
Patent dated December 22, 1936. Disclaimer filed January 8, 1938, by
the assignee, *General Electric Company*.

Hereby disclaims claims 1 and 11 of said Letters Patent.
[*Official Gazette February 1, 1938.*]